# SEDAR 12 Advisory Report
## Gulf of Mexico Red Grouper

*Stock Distribution and Identification*

This assessment applies to red grouper within US waters of the Gulf of Mexico. The Gulf of Mexico and South Atlantic stocks are divided along the Florida Keys.

*Assessment Methods*

Three modeling approaches are considered in this assessment: a surplus production model (ASPIC), a forward projection age-structured model (ASAP), and a stochastic stock reduction analysis (SRA). A Virtual Population Analysis (VPA) was consulted to evaluate assumptions and configuration options regarding changes and catchability and selectivity for the age structured model.

The forward projection catch-age model using the ASAP software was chosen for evaluating stock status and providing management advice. The Review Panel recommended ASAP configuration is detailed in the Consensus Summary. The Panel's recommended configuration includes time-varying catchability, adjusted natural mortality scaling, incorporation of the NMFS longline survey, and reduced influence by the derived discard age composition.

*Assessment Data Summary*

The base assessment includes data from 1986 - 2005. The fishery is divided into four fleets and the population is modeled over ages 1 - 20 with the final age (20) treated as a plus group. Specific data sources included in the ASAP model and the years over which information is available are summarized as follows:

Landings (fleets):
- Commercial longline, 1986- 2005
- Commercial handline, 1986-2005
- Commercial trap, 1986-2005
- Recreational, 1986 - 2005 (MRFSS and headboat combined)

Discards:
- Commercial, by fleet 1990-2005
- Recreational, 1986-2005
- Discards estimated in numbers for both recreational and commercial fleets are converted to weight (gutted pounds) using the estimated age composition and the growth model.

Length & Age Composition:
- The assessment model accepts direct age composition information available from otolith sampling of the fisheries. Otolith sampling is sporadic across years and fisheries between 1986 and 1991. Sampling intensity increases considerably for 1991 and later. All available otolith samples are used for evaluating age composition.
- Discard age composition is provided through an iterative probabilistic modeling approach.

Indices :
- Commercial longline CPUE, 1990-2005

Commercial handline CPUE, 1990-2005
MRFSS recreational CPUE, 1986-2005
Headboat CPUE, 18" size limit, 1986-1990
Headboat CPUE, 20" size limit, 1991-2005
SEAMAP Video, 1993-2005 (years incomplete)
NMFS Longline, 2000-2005 (years incomplete)

Life History:

Natural mortality is set at a base M=0.14. Specific values vary across ages based on a scaled Lorenzen curve.

Reproductive information (maturity, fecundity, and sex ratio) is updated from previous assessments to incorporate results from several recent studies.

Discard mortality rates are updated from previous assessments to incorporate results of recent research. Estimated mortality on discards is 0.4 for the longline fleet and 0.1 for all other components

*Catch Trends*

Total landings are variable with an overall declining trend during the start of the assessment period, falling from nearly 9 million pounds (mp) in the initial year 1986 to the period low of 4.6 mp in 1998. Total landings then increase sharply, nearing 8 million pounds in 1999 and stabilizing thereafter. Total landings observed between 1999 and the terminal year 2005 averaged 7.5 million pounds which compares favorably to the estimated Optimal Yield (OY) of 7.6 million pounds.

Commercial longline landings gradually increase during the 1986-2005 assessment period. Landings during the late 1980's through early 1990's are more variable than in later years, therefore both the high (4.3 mp in 1993) and the low (2.0 mp in 1990) observed values occur within a few years.

Commercial handline landings decline considerably over the assessment period, falling from 3.74 million pounds in 1990 to less than 1 million pounds in 1998. Handline landings increase by 2000 to the current level around 1.5 million pounds.

Commercial trap landings are considerably lower than either handline or longline, seldom exceeding 1 mp over the assessment period.

Recreational landings including all components are slightly less than total commercial landings. With the exception of the 1995-1997 period when landings were considerably less than average at 0.5 mp, recreational landings vary between 1 and 3 mp.

*Fishing Mortality Trends*

Annual estimates of instantaneous fishing mortality (F) reported for each fishery, including those for both discard and directed components, are apical or peak values observed across all ages for the given fishery and year. This is analogous to 'fully recruited' fishing mortality.

Total apical fishing mortality for all directed fleets combined is estimated at F=0.18 in 1986 at the start of the analytical period. Fishing mortality increases steadily in the early portion of the series, reaching a peak of F=0.30 in 1993 before falling steadily to F=0.15 in 1998. Fishing mortality increases slightly in 1999 to around F=0.2, although a downward trend since 2000 ends with a terminal estimate of F=0.15 for 2005.

Mortality attributed to the commercial longline fishery increases over the early portion of the assessment period, from a low of F=0.07 in 1986 to a high of F=0.17 in 1993. Longline mortality thereafter declines, falling to F=0.1 in the terminal year (2005). Fishing mortality contributed by the commercial handline fishery exhibits a pattern similar to that of the commercial longline, reaching a peak F=0.1 in 1990 before declining steadily to the terminal estimate of F=0.04. Commercial trap mortality is variable, but generally below F=0.07.

Recreational mortality estimates also peak during the middle of the assessment period, initially rising from F=0.01 in 1986 to the observed peak in 1992 of F=0.15 before falling to the minimum observed F=0.04 in 1997. Mortality increases slightly thereafter, reaching F=0.11 in 2004 and averaging 0.08 during 1998-2005.

Fishing mortality attributed to discards is typically only around 10% of that attributed to landings, with peak values of $F_{DISCARD}$=0.03 (all fleets combined) occurring during 1990-1994.

*Stock Abundance and Biomass Trends*

Total stock abundance averages 27.6 million fish and varies with little trend between 1986 and 1999. However, abundance jumps sharply in 2000 to 40.5 million fish as the strong 1999 year class enters the estimated population at age 1. Total abundance tapers off gradually thereafter to the terminal estimate of 31.7 million fish for 2005.

Spawning stock is measured as total female gonad weight. Estimated spawning stock gradually improves over the assessment period, from just below 500 metric tons (mt) of eggs in late 1980's to over 700 mt in the last few years which include the observed high of 752 mt of eggs in 2005.

Estimated recruitment at age 1 exhibits two notably strong year classes (1996 and 1999) but little overall trend otherwise. Recruitment over the assessment period averages 9.6 million fish, with peak values of 13 million in 1997 and 22 million in 2000.

*Status Determination Criteria*

Management benchmark recommendations are based on the Review Panel's chosen model configuration as described here and in the consensus summary.

*Status Determination Table*

| Criteria | Recommended Values[1] | |
|---|---|---|
| | Definition | Value |
| MSST (egg weight) | $(1\text{-}M)SS_{MSY}$ | 509 mt |
| MFMT (apical F) | $F_{MSY}$ | 0.21 |
| MSY (gutted weight) | Yield at $F_{MSY}$ | 7.72 mp |
| $F_{MSY}$ | $F_{MSY}$ | 0.21 |
| OY (gutted weight) | Yield at $0.75*F_{MSY}$ | 7.6 mp |
| $F_{OY}$ | $0.75*F_{MSY}$ | 0.16 |
| M (base) | -- | 0.14 |

*1. Note that reference points and yield reflect only directed fisheries landings. There is an additional allowance for estimated discards.*

*Stock Status*

The Gulf of Mexico stock of red grouper was not overfished and was not experiencing overfishing in 2005.

The stock is considered recovered based on estimated spawning stock in excess of the MSY level as of January 1, 2005. Current model estimates indicate the stock ceased being overfished in 1992 when the spawning stock exceeded the MSST, and reached recovered status 7 years later in 1999 when the spawning stock exceeded the level associated with MSY. Increases in the spawning stock observed over the last 5 years are largely due to recent strong year classes and therefore represent a trend which may not continue into the future.

Current model estimates indicate the stock has not experienced overfishing since 1994. Exploitation dropped to target levels ($F_{OY}$) in 1997 and 1998, then climbed above $F_{OY}$ during most years thereafter. Exploitation in 2005 is 97% of $F_{OY}$.

Stock status determinations relative to current estimates for benchmark values are summarized in the *Status Summary Table* below.

*Status Summary Table*

| Criteria | Value |
|---|---|
| $SS_{MSY}$ (MT eggs) | 591 |
| $SS_{2005}$ (MT eggs) | 752 |
| $SS_{2005}/SS_{MSY}$ | 1.27 |
| $SS_{2005}$/MSST | 1.48 |
| $F_{MSY}$ (MFMT) | 0.21 |
| $F_{OY}$ | 0.16 |
| $F_{2005}$ | 0.16 |
| $F_{2005}$/MFMT | 0.73 |
| $F_{2005}/F_{OY}$ | 0.97 |

*Projections*

Short term projections (2006 - 2015) were prepared to evaluate a range of future fishing mortality ($F_{MSY}$, $F_{OY}$, $F_{current}$) and harvest strategies (OY, current harvest limit). Projections were prepared assuming management changes could take place in 2008, selectivity remains constant for all fisheries, and discard rates remain constant for all fisheries. Future recruitment is estimated from the average estimated over the assessment period.

Projection results indicate spawning stock will remain above $SS_{MSY}$ and fluctuate around its current level through at least 2015 if fishing mortality and total removals are held at current conditions which are consistent with management at the stated optimal yield. Spawning stock will decline to $SS_{MSY}$ levels by 2015 if mortality increases to $F_{MSY}$. Fishing mortality will stabilize near the current level, which is just below $F_{OY}$, if landings are maintained at either current or OY levels.

*Allowable Biological Catch*

Because overfishing is not occurring and estimated spawning stock exceeds the MSY spawning stock level, Allowable Biological Catch (ABC) levels are recommended

based on exploitation at $F_{OY}$. Point estimates of ABC exceed OY for the near future due to high current stock abundance caused in part by the strong 1999 cohort. The long-term sustainability of catch limits in excess of predicted OY will depend on how future recruitment compares to the long term average used in the projection analyses.

Annual deterministic ABC for landings only, including 80% confidence intervals. Values are millions of gutted pounds.

| YEAR | ABC (landings) | Lower | Upper |
|---|---|---|---|
| 2008 | 7.97 | 7.97 | 7.97 |
| 2009 | 7.94 | 7.88 | 8.03 |
| 2010 | 7.89 | 7.68 | 8.26 |
| 2011 | 7.84 | 7.43 | 8.52 |
| 2012 | 7.79 | 7.22 | 8.84 |
| 2013 | 7.75 | 7.09 | 9.07 |
| 2014 | 7.72 | 7.03 | 9.21 |
| 2015 | 7.69 | 7.02 | 9.35 |

*Uncertainty*

Uncertainty is evaluated though confidence intervals calculated on key model output, sensitivity analyses used to examine configuration alternatives, and retrospective analyses used to examine terminal year effects. The 95% confidence interval on current stock status is approximately +- 14% of the mean estimate, although this estimate of the confidence interval does not include all potential factors that could contribute to the uncertainty. The RP finds that the level of natural mortality and the degree of drift in fishery catchability are influential aspects of the model configuration and appropriate sensitivity analyses to alternative levels of these configuration factors have been provided. Retrospective bias is most noticeable in estimates of exploitation and recruitment. A likely source of the retrospective bias is recruitment uncertainty during each cohort's youngest ages that is attributed to a lack of independent survey information prior to age 3. The cause of apparent retrospective bias in fishing mortality is more difficult to ascertain, but one likely factor is the relatively short time series of adequate age sampling.

The RP finds that the degree of uncertainty in the red grouper stock assessment is not so high as to interfere with the use of these results as the technical basis for management of this stock. The current management plan sets the target level of the fishery at 75% of the best estimate of the fishing mortality limit. Such a buffer is consistent with the degree of uncertainty in this assessment.

*Special Comments*

The Review Panel finds that the red grouper assessment in 2006 is a significant improvement over the assessment conducted in 2002 and addresses certain deficiencies directed at previous assessments. In particular, the addition of longer time series of indices improved estimates of long term trends, while direct age composition data has greatly improved estimates of year-to-year changes in recruitment and allowed modification of natural mortality levels. Improved age composition data and additional years of analysis enable the assessment to track recent recruitments, notably the large

recruitment from the 1999 year class. However, lack of a pre-recruit survey prevents detection of recruitment fluctuations past 2002.

Some revision of historical stock status estimates has occurred, and the RP finds that the magnitude of these changes is not unexpected given the degree of uncertainty in the estimates. Management measures and other factors that influence the level of fishing activity, and therefore fishing mortality (F), have resulted in recent levels of F that are quite close to the F level that would produce optimum yield (OY). This conclusion is derived from model results that are clearly supported by the stable or upward trends in the fishery CPUE and survey indicator data, and in the fishery age composition data which indicate a broad age distribution with an increasing number of older fish appearing in the fishery and continued occurrence of new recruits. Management measures have successfully maintained observed landings over the last 7 years near the optimal yield level. Recent strong recruitment events, such as the 1999 year class, contribute significantly to the recent increase in spawning stock measures.

Table 1. Landings and discards[1] by sector in gutted pounds, 1986 – 2005.

| | Landings | | | Dead Discards[1] | | | Removals (Landings + Dead Discards) | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR | Commercial | Recreational | Total Landings | Commercial | Recreational | Total Dead Discard | Total Commercial | Total Recreational | Total Removals |
| 1986 | 6,312,986 | 2,400,380 | 8,713,366 | 0 | 20,657 | 20,657 | 6,312,986 | 2,421,037 | 8,734,023 |
| 1987 | 6,717,890 | 1,464,710 | 8,182,600 | 0 | 19,021 | 19,021 | 6,717,890 | 1,483,731 | 8,201,621 |
| 1988 | 4,742,496 | 2,476,070 | 7,218,566 | 0 | 34,758 | 34,758 | 4,742,496 | 2,510,828 | 7,253,324 |
| 1989 | 7,367,911 | 2,761,150 | 10,129,061 | 0 | 81,650 | 81,650 | 7,367,911 | 2,842,800 | 10,210,711 |
| 1990 | 4,809,282 | 1,131,710 | 5,940,992 | 733,671 | 228,556 | 962,227 | 5,542,953 | 1,360,266 | 6,903,219 |
| 1991 | 5,094,501 | 1,775,110 | 6,869,611 | 1,155,185 | 407,354 | 1,562,539 | 6,249,686 | 2,182,464 | 8,432,150 |
| 1992 | 4,463,277 | 2,658,180 | 7,121,457 | 721,264 | 356,598 | 1,077,862 | 5,184,541 | 3,014,778 | 8,199,319 |
| 1993 | 6,379,626 | 2,091,160 | 8,470,786 | 732,983 | 234,183 | 967,166 | 7,112,609 | 2,325,343 | 9,437,952 |
| 1994 | 4,902,862 | 1,808,240 | 6,711,102 | 446,280 | 224,934 | 671,214 | 5,349,142 | 2,033,174 | 7,382,316 |
| 1995 | 4,746,140 | 1,862,570 | 6,608,710 | 601,308 | 225,097 | 826,405 | 5,347,448 | 2,087,667 | 7,435,115 |
| 1996 | 4,454,146 | 893,755 | 5,347,901 | 566,243 | 159,758 | 726,001 | 5,020,389 | 1,053,513 | 6,073,902 |
| 1997 | 4,848,486 | 562,328 | 5,410,814 | 623,516 | 149,181 | 772,697 | 5,472,002 | 711,509 | 6,183,511 |
| 1998 | 3,948,566 | 643,058 | 4,591,624 | 543,057 | 208,428 | 751,485 | 4,491,623 | 851,486 | 5,343,109 |
| 1999 | 5,974,706 | 1,152,810 | 7,127,516 | 734,532 | 283,487 | 1,018,019 | 6,709,238 | 1,436,297 | 8,145,535 |
| 2000 | 5,838,300 | 2,107,730 | 7,946,030 | 621,851 | 300,042 | 921,893 | 6,460,151 | 2,407,772 | 8,867,923 |
| 2001 | 5,964,506 | 1,327,770 | 7,292,276 | 756,182 | 223,726 | 979,908 | 6,720,688 | 1,551,496 | 8,272,184 |
| 2002 | 5,907,248 | 1,611,110 | 7,518,358 | 726,561 | 260,670 | 987,231 | 6,633,809 | 1,871,780 | 8,505,589 |
| 2003 | 4,937,970 | 1,275,830 | 6,213,800 | 623,068 | 283,721 | 906,789 | 5,561,038 | 1,559,551 | 7,120,589 |
| 2004 | 5,749,039 | 3,000,140 | 8,749,179 | 812,431 | 421,755 | 1,234,186 | 6,561,470 | 3,421,895 | 9,983,365 |
| 2005 | 5,410,594 | 1,630,140 | 7,040,734 | 894,328 | 243,491 | 1,137,819 | 6,304,922 | 1,873,631 | 8,178,553 |

1. Information on the size of discards from the various fisheries is not available; the amounts presented here are based on assumptions about the age composition (as used in the assessment) and their weight at age.

Table 2. Estimated total annual fishing mortality attributed to both landings and discard components with stock status evaluations relative to MFMT and $F_{OY}$.

| | APICAL F[1] | | Relative Fishing Mortality[2] (Landings) | |
|---|---|---|---|---|
| YEAR | LANDINGS | DISCARD | F/Fmsy | F/Foy |
| 1986 | 0.18 | 0.01 | 0.84 | 1.13 |
| 1987 | 0.19 | 0.01 | 0.87 | 1.16 |
| 1988 | 0.16 | 0.01 | 0.76 | 1.02 |
| 1989 | 0.23 | 0.01 | 1.06 | 1.41 |
| 1990 | 0.20 | 0.03 | 0.95 | 1.27 |
| 1991 | 0.23 | 0.03 | 1.09 | 1.46 |
| 1992 | 0.23 | 0.03 | 1.08 | 1.44 |
| 1993 | 0.27 | 0.03 | 1.25 | 1.67 |
| 1994 | 0.22 | 0.03 | 1.02 | 1.36 |
| 1995 | 0.20 | 0.02 | 0.96 | 1.28 |
| 1996 | 0.16 | 0.02 | 0.77 | 1.03 |
| 1997 | 0.16 | 0.02 | 0.74 | 0.98 |
| 1998 | 0.13 | 0.02 | 0.62 | 0.83 |
| 1999 | 0.18 | 0.02 | 0.85 | 1.13 |
| 2000 | 0.19 | 0.02 | 0.90 | 1.19 |
| 2001 | 0.18 | 0.02 | 0.86 | 1.14 |
| 2002 | 0.18 | 0.02 | 0.85 | 1.14 |
| 2003 | 0.16 | 0.02 | 0.73 | 0.97 |
| 2004 | 0.18 | 0.02 | 0.84 | 1.13 |
| 2005 | 0.16 | 0.02 | 0.73 | 0.97 |

1. Landings and discard Fs are additive. Apical F reflects the maximum annual value across ages for all fleets combined.
2. Relative fishing mortality used to evaluated stock status is determined based on the landings component.

Table 3. Stock abundance, age-1 recruitment, spawning stock, and spawning stock status.

| | Spawning Stock | | | Abundance (Millions of fish) | |
|---|---|---|---|---|---|
| YEAR | SS (Metric Tons[1]) | Status SS/MSST | Status $SS/SS_{MSY}$ | Total Stock | Recruitment (Age 1) |
| 1986 | 506 | 0.99 | 0.85 | 23.11 | 6.07 |
| 1987 | 485 | 0.95 | 0.82 | 27.73 | 12.45 |
| 1988 | 473 | 0.93 | 0.80 | 29.91 | 11.77 |
| 1989 | 476 | 0.94 | 0.81 | 27.98 | 8.35 |
| 1990 | 475 | 0.93 | 0.80 | 29.60 | 11.52 |
| 1991 | 500 | 0.98 | 0.84 | 30.22 | 10.17 |
| 1992 | 531 | 1.04 | 0.90 | 29.13 | 8.71 |
| 1993 | 549 | 1.08 | 0.93 | 26.32 | 6.53 |
| 1994 | 550 | 1.08 | 0.93 | 24.99 | 7.02 |
| 1995 | 567 | 1.11 | 0.96 | 26.14 | 8.87 |
| 1996 | 561 | 1.10 | 0.95 | 24.91 | 6.97 |
| 1997 | 568 | 1.12 | 0.96 | 31.23 | 13.81 |
| 1998 | 582 | 1.15 | 0.98 | 28.71 | 7.40 |
| 1999 | 618 | 1.21 | 1.04 | 25.83 | 5.60 |
| 2000 | 639 | 1.26 | 1.08 | 40.57 | 22.34 |
| 2001 | 626 | 1.23 | 1.06 | 34.78 | 7.98 |
| 2002 | 660 | 1.30 | 1.12 | 31.85 | 7.72 |
| 2003 | 700 | 1.38 | 1.18 | 32.02 | 9.65 |
| 2004 | 734 | 1.44 | 1.24 | 32.49 | 10.03 |
| 2005 | 752 | 1.48 | 1.27 | 31.70 | 9.33 |

1. Spawning stock is measured in mature female gonad weight.

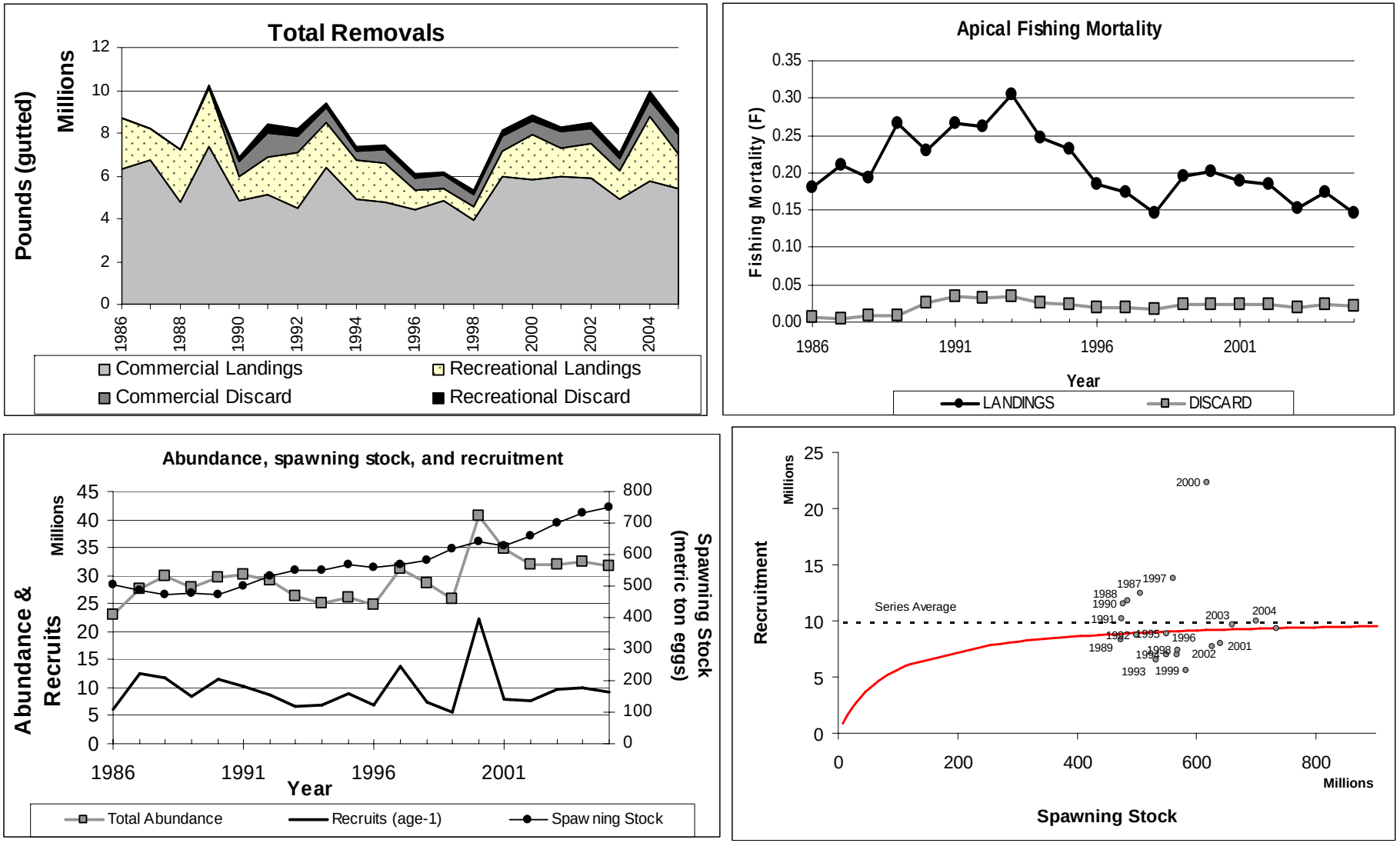
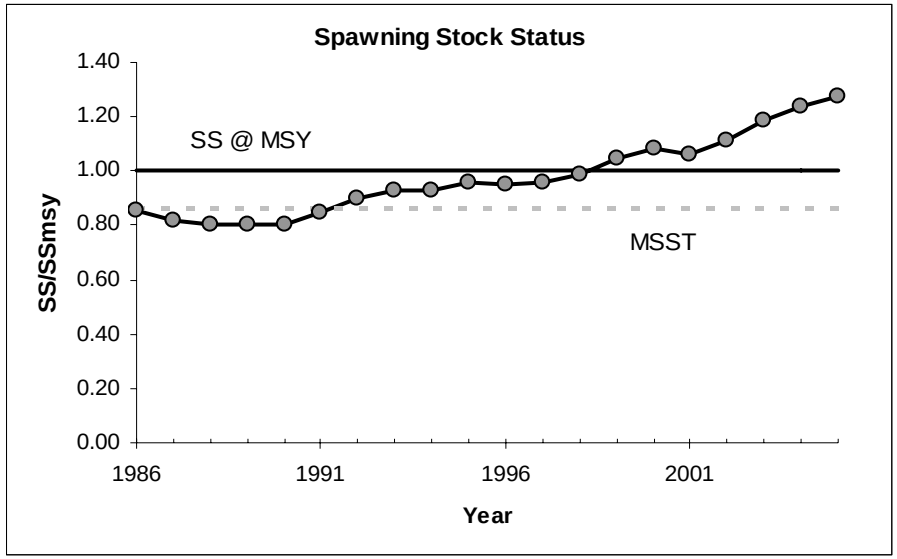
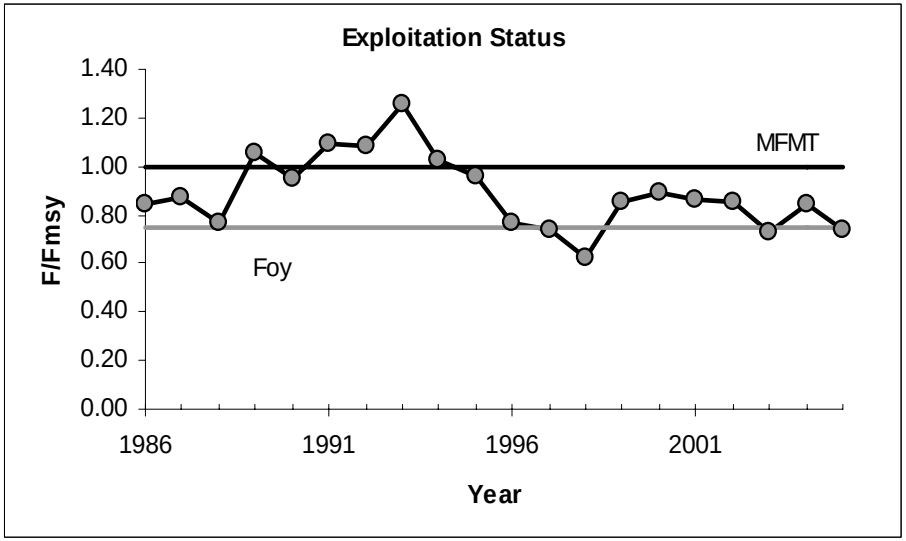
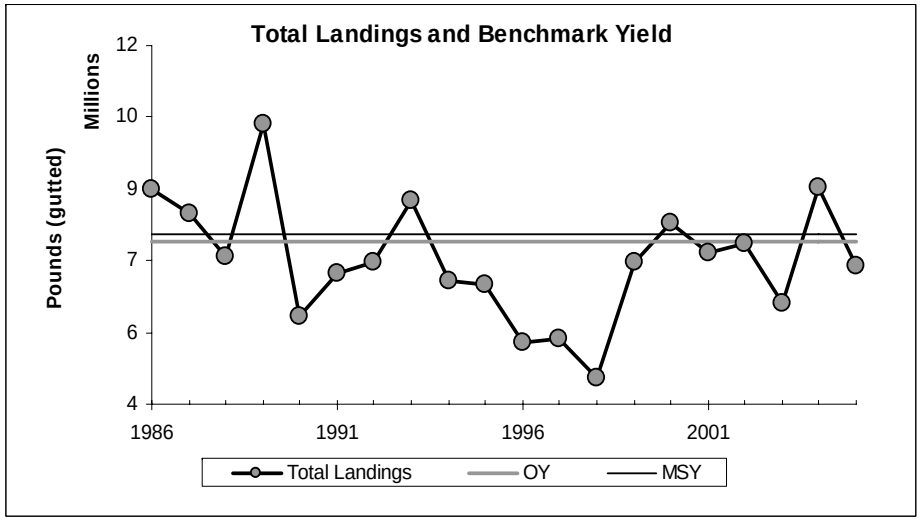



Figure 1. Stock estimates. Total removals in gutted pounds by fishery (upper left); total apical fishing mortality attributed to discard and directed removals (upper right); time series of important population parameter estimates including recruits at age 1, total abundance in numbers, and spawning stock egg weight (lower left); stock recruitment plot showing annual estimates (points) predicted relationship (solid line) and series average (dashed line).



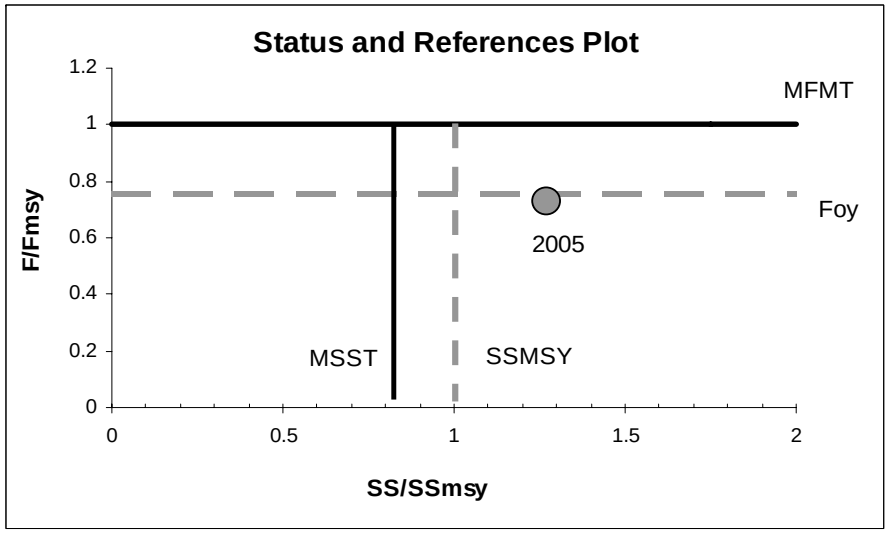




Figure 2. Population management benchmarks and status. Spawning stock relative to MSY level with reference lines for MSST and MSY (stock recovery)(upper left); exploitation compared to target and limit exploitation levels (upper right); phase plot comparing current status and management reference levels (lower right); Total landings compared to estimated benchmark landings (upper left).

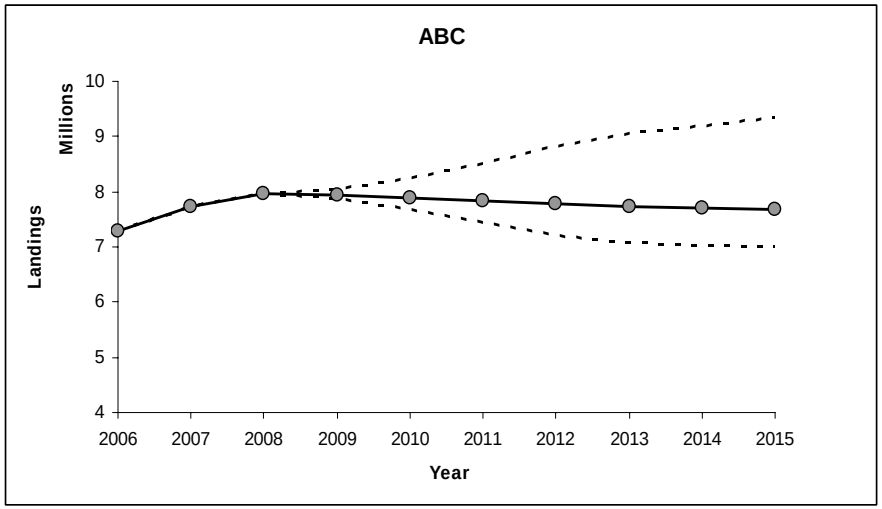



Figure 3. Estimated future landings (ABC) based on exploitation at $F_{OY}$ including 80% confidence intervals based on recruitment deviations.

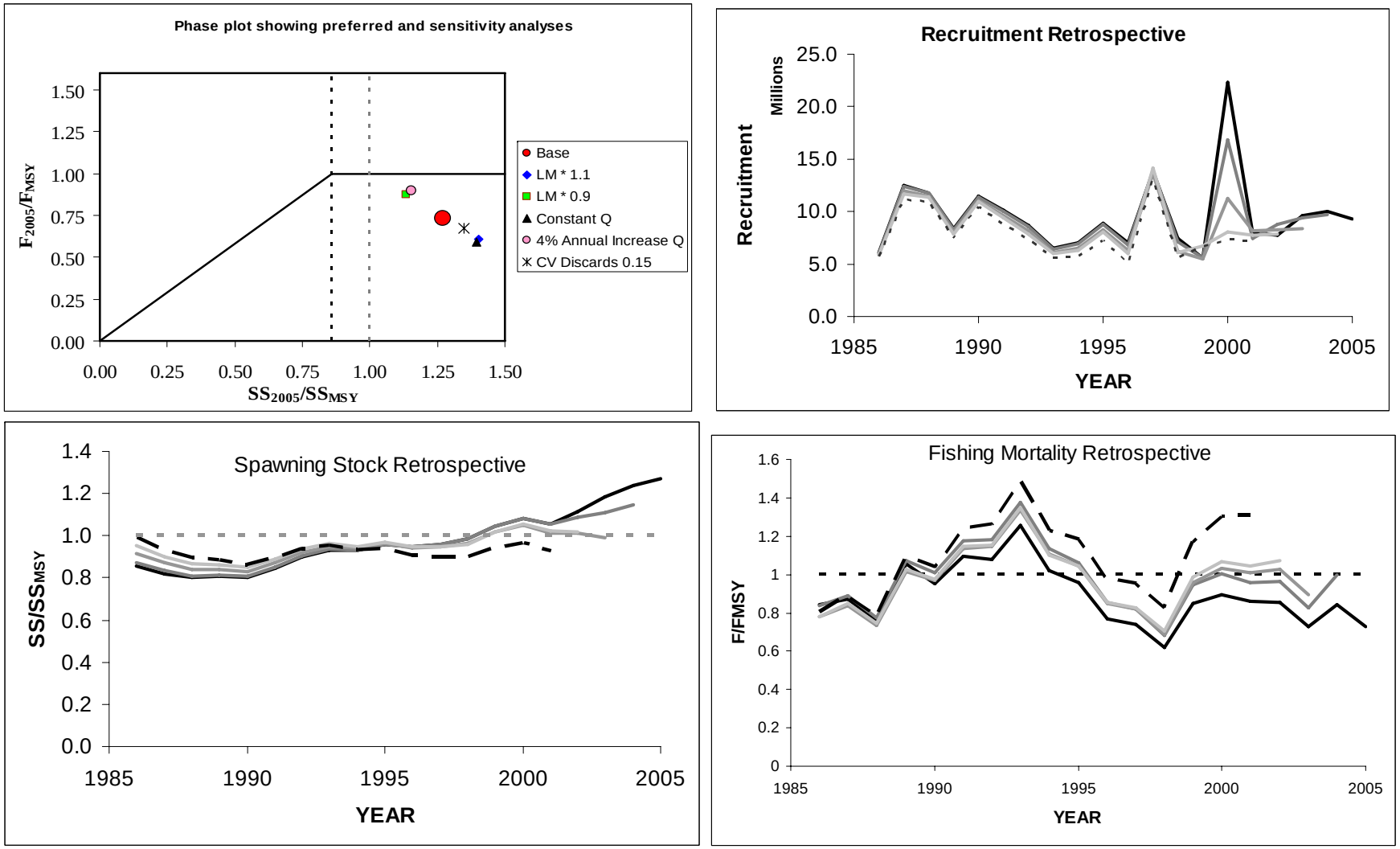



Figure 3. Illustrated model uncertainties. Point estimates of terminal stock status relative to management limits for base and review sensitivity runs (upper left panel); results of retrospective analyses for recruitment (upper right) spawning stock (lower left) and exploitation (lower right)